

Transcontinental Gas Pipe Line Company, LLC – Compressor Station 130 TV Renewal

It is classified as a major source under PSD/NSR regulations because potential to emit (PTE) for nitrogen oxides (NO_x), carbon monoxide (CO), and volatile organic compounds (VOC) is greater than 250 tons per year, each.

The facility has 21 IC engines (pre-CAA) and two turbines. Natural gas enters the facility in pipelines. Compressors increase the pressure of the gas for transmission in the pipelines downstream of the compressor station.

The facility has undergone a PSD review for Mainline Unit 18 (Turbine G1) in 1993. Conditions 3.2.1 and 3.2.3 contain the PSD Best Available Control Technology (BACT) limits for Turbine G1.

Mainline Unit 17 (Turbine T1) is subject to the NO_x PSD avoidance limit specified in Condition 3.2.2

Facilitywide Emissions:

NO_x 4,140 tpy

CO 1,150 tpy

VOC 398 tpy

GHG 260,000 tpy

PM/PM₁₀ 66.7 tpy

SO₂ 3.20 tpy

Single HAP (Formaldehyde) 183 tpy

Combined HAP 264 tpy

No control devices are in use at the facility therefore CAM is not applicable.

Condition 3.3.9 of the permit contains a formaldehyde emission limit according as specified in 40 CFR 63.6612(a) which also requires the facility to conduct the performance testing specified in Tables 4 and 5 in that subpart. Table 4 includes applicable test methods for this facility

Method 320 or 323 is to be used to determine formaldehyde emission/concentration. These test methods are included in permit Condition 4.1.3.

Item 13.a.i. of Table 5 of 40 CFR 63.6612(a) requires an initial performance test for AC01 and AC02.(compressors). This testing requirement is included in newly added Condition 4.2.3, and must be conducted within 180 days of the compliance date, October 19, 2013. Also, per 40 CFR 63.6620(d), the condition requires three 1-hr test runs per test performed.

Citizens have raised the question of the facility's emissions being absent from the TRI. Toxic Release Inventory (TRI) reporting requirements, 40 CFR part 372, do not apply to the facility because the North American Industrial Classification System (NAICS) code is 486210, which is not a covered NACIS code in 40 CFR part 372.23.

General comments: (from enforcement) on clarification in permit on applicability of standards to specific units and the reason for MACT exempt status of some units, which is clear in the SOB: The Statement of Basis (SOB) for the permit states the following:

3. *MACT Standards*

The facility is a major source for single HAP and combined HAPs because each PTE for acetaldehyde, acrolein, and formaldehyde is greater than 10 tpy, respectively, and the PTE for combined HAPs is greater than 25 tpy.

Mainline Units 17 and 18 (Turbines T1 and G1) are subject to 40 CFR 63, Subpart YYYY – “National Emission Standards for Hazardous Air Pollutants for Stationary Combustion Turbines.” According to 40 CFR 63.6090(a)(1) and 63.6090(b)(4), Turbines T1 and G1 are existing units and do not have to meet the requirements of this Subpart. No initial notification is necessary for any existing stationary combustion turbine.

Mainline Units 1 through 16 (ID Nos. ML01 – ML16), Air Compressors AC01 and AC02, and Auxiliary Generators AUX1 – AUX3 are all subject to 40 CFR 63, Subpart ZZZZ – “National Emission Standards for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines.” According to the narrative that explained Title V Permit No. 4922- 195-0015-V-02-0, all mainline unit engines are spark ignition (SI) 2 stroke lean burn (2- SLB) engines while the other engines are SI 4 stroke rich burn (4-SRB) engines. According to 40 CFR 63.6590(a)(1)(i) and 63.6590(b)(3)(i), each of ML01 – ML16 is an existing 2-SLB engines with a capacity greater than 500 horsepower (Hp) at a HAP major source and does not have to meet the requirements of this Subpart. No initial notification is necessary for any existing 2-SLB engine. AC01, AC02, and AUX1 – AUX3 are subject to the requirements of 40 CFR 63 Subpart ZZZZ. Please refer to Section III.C. of this narrative for a detailed discussion.

Although the SOB statement above explains why the Mainline units are exempt from MACT Subpart ZZZZ, the Title V Permit [Part 3.0 Requirements for Emission Units] lists all of the Mainline Units, the Air Compressors, and the Auxiliary Generators as subject to MACT Subpart A and Subpart ZZZZ, without a notation of exemption from the regulatory requirements. The listing of each unit in Part 3.0 contains information on the engine horsepower and the date of installation. However, the listing does not state the engine ignition type (i.e. spark ignition) and whether the engine is lean or rich burn. The ignition and burn types determine applicability under MACT Subpart ZZZZ. In Part 1.0 [Facility Description] under Part 1.3 [Overall Facility Process Description], the narrative states that “[a]ll turbines and engines fire natural gas exclusively. All mainline compressor engines (ID Nos. ML01 through ML16) are spark ignition 2-stroke lean burn (2-SLB) reciprocating internal combustion engines. The air compressor engines with ID Nos. AC01 and AC02 and the auxiliary generator engines with ID Nos. AUX1 through AUX3 are spark ignition 4-stroke rich burn (4-SRB) reciprocating internal combustion engines.”

It is recommended that, to clarify applicability, a statement of applicability should be explicitly made and the ignition and fuel burn characteristics should be clearly identified in the listing of each specific unit.

Concerns with Nitrogen Oxide (NOx) Emissions and Formaldehyde:

The 16 engines that drive the natural gas compressors are 1950 to 1971 era 2 stroke lean burn large bore engines that burn pipeline quality natural gas. Unlike diesel or gasoline engines, 2 stroke natural gas engines burn large amounts of lubricating oil, with 0.0002 – 0.002 pounds/horsepower hour for a Waukesha brand engine for example. For the 2,050 horsepower Mainline Units (ML01-ML13) running at 70% load the engines burns approximately 1.6 pounds/hour. With 80% uptime this amounts to 11,213 pounds per year each and 220,000 lb/yr for all 16 engines combined. The combustion of the complex hydrocarbons in the lubricating oil and the use of large bore engines¹ is the source of de novo formation of formaldehyde in the total hydrocarbon level in the exhaust. The combustion of the lubricating oil also contributes to the production of NOx, primarily by increasing combustion temperature, but it is not the most important factor. The engines are typically run at higher loads causing higher temperatures and with large yearly uptime. These two factors are the primary reason why the large amounts of NOx are emitted from this facility.

Footnotes:

1. Daniel B. Olsen and Charles E. Mitchell state in, *Formaldehyde Formation in Large Bore Engines Part 2: Factors Affecting Measured CH₂O*, J. Eng. Gas Turbines Power - October 2000 - Volume 122, Issue 4, 611 (6 pages):

“Current research shows that the only hazardous air pollutant of significance emitted from large bore natural gas engines is formaldehyde (CH₂O). A literature review on formaldehyde formation is presented focusing on the interpretation of published test data and its applicability to large bore natural gas engines. The relationship of formaldehyde emissions to that of other pollutants is described. Formaldehyde is seen to have a strong correlation to total hydrocarbon (THC) level in the exhaust. It is observed that the ratio of formaldehyde to THC concentration is roughly 1.0–2.5 percent for a very wide range of large bore engines and operating conditions”

For FYI Only:

The stack test NOx emission rates for the mainline reciprocal ignition compression engines vary over a wide ratio of 11.9 between 181.5 to 15.26 pounds per hour (Unit ID: ML16/ML01). The stack test CO emission rates vary over ratio of 3.96 between 45.75 to 9.965 pounds per hour (Unit ID: ML16/ML01). The large variability is partially explained by the fact the engine with the larger emission rate, i.e., ML16, is a larger engine with a higher design heat input capacity (e.g., 37.7 vs 15.4mmBtu/hr or 5,500 vs 2050 hp). Correcting for heat input, the NOx ratio comes down to 4.86 and CO to 1.62. The remainder of the variability of NOx compared to CO comes from the fact these engines were installed in 1971 for ML16 and in 1950 for ML01 and they have different 2 stroke lean burn engine designs that combust varying portions of their

lubricating oil. Newer designed engines run richer than older engine designs to save on fuel costs. An engine that burns leaner has more complete combustion and lower combustion temperature through air dilution, thus lowering both the production rates. This is a main factor why the 1950 engine has lower NO_x and CO emission rates than the 1971 engine. The variability in the rates of combustion of the lubricating oil also contributes to the production of NO_x, primarily by increasing combustion temperature, but it is not the most important factor.

Transcontinental Gas Pipe Line Company, LLC (Transcon) Notes:

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<http://www.machinerylubrication.com/Read/524/natural-gas-engine-oil-analysis>

Oil Consumption Rates

It is important to note that unlike diesel or gasoline engines, natural gas engines can burn large quantities of lubricating oil during operation. The typical oil consumption rate for the Waukesha natural gas engine is 0.0002 - 0.002 pounds/horsepower-hour (0.091-0.910 grams/horsepower-hour).

These oil consumption rates can be determined for any natural gas engine using the following formulas, with the results then compared to the engine manufacturer’s typical consumption rates.

$$\begin{array}{rcl} \frac{\text{lbs}}{\text{hp-hr}} & = & \frac{7.3 \times \# \text{ Gallons Oil Used}}{\text{hp} \times \text{Hours of Operation}} \\ \frac{\text{lbs}}{\text{hp-hr}} & = & \frac{1.82 \times \# \text{ Quarts Oil Used}}{\text{hp} \times \text{Hours of Operation}} \\ \frac{\text{grams}}{\text{hp-hr}} & = & \frac{875 \times \# \text{ Litres Oil Used}}{\text{hp} \times \text{Hours of Operation}} \end{array}$$

It is important to consider a natural gas engine’s oil consumption rate. The oil analysis interpretation results may be misunderstood if consumption is not taken into account because the addition of make-up oil dilutes wear particle concentrations and contaminant levels.

The primary difference between natural gas and other internal combustion engine oils is the necessity to withstand the various levels of oil degradation caused by the gas fuel combustion process, which results in the accumulation of oxides of nitrogen. This condition, commonly

called nitration, must be monitored regularly if both lubricant and engine life are to be maintained.

Nitration and Oxidation

Nitration and oxidation are naturally occurring processes within natural gas engine oils that can be quite severe, depending upon conditions such as air-to-fuel ratios and oil operating temperatures.

Oxidation is caused by the reaction of oil with oxygen in combination with such catalysts as copper wear particles, particularly as oil temperatures increase above 200°F (95°C). Oxidation occurs to some degree in all lubricated systems and results in an increase in the oil's viscosity.

Nitration on the other hand, occurs most frequently in natural gas engines and if left uncontrolled, can cause serious problems, including the complete solidification of the oil.

Nitration is a chemical reaction within the oil, which causes the carbon chains to react with nitrogen dioxide (NO₂) formed during natural gas combustion, causing serious and premature thickening of the oil. This results in the formation of severe varnish and carbon deposits. Once begun, the condition worsens exponentially.

There are two major factors that must be carefully controlled if excessive nitration is to be prevented. The first is the oil's operating temperature. Nitration becomes significant at oil reservoir temperatures of about 135°F (57°C) and becomes even more dramatic at lower temperatures. (Natural gas engines must be operated with oil temperatures in a range of 180°F to 185°F (82°C to 85°C) in order to control both nitration and oxidation.)

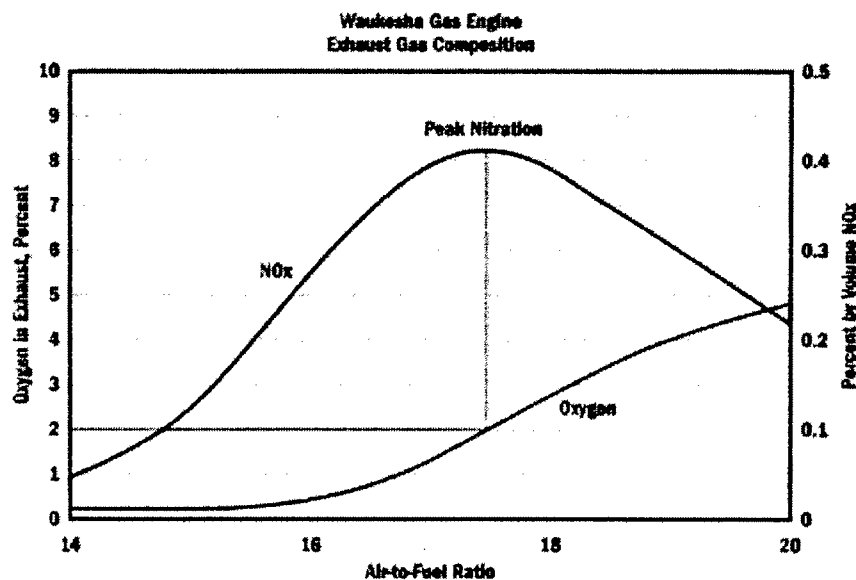


Figure 2. Operators Select the Air-to-Fuel Ratio for the Application or Conditions Required.

The second major consideration in the prevention of nitration is the air-to-fuel ratio, which has the greatest effect on nitration rates. Nitration peaks at air-to-fuel ratios of 18-to-1 or 19-to-1, depending upon engine type and fuel condition. As Figure 2 illustrates, a rich ratio of 15.5-to-1 is used for best horsepower in a Waukesha gas engine, while a more lean mixture of 17-to-1 is used for greatest economy. At a ratio of 17-to-1, nitration will occur. In the newer, lean-burn designed

engines with ratios of 20-to-1 or leaner, nitrogen oxides are not released, which effectively and dramatically reduces or eliminates nitration.

It is for this reason that the use of either direct infrared spectroscopy, or Fourier Transform infrared (FTIR) oil analysis techniques are highly recommended for natural gas engine oils. The techniques compare samples of the used oil with a reference sample of new oil. The testing instruments chart a curve which represents the difference between the used and new reference samples.

The chart's curve will immediately point out any contamination, nitration or oxidation conditions. A high concentration of nitration can be used as a indication that a tune up is necessary, because nitration is primarily caused by air-to-fuel ratio, or engine temperature problems (Figure 3).

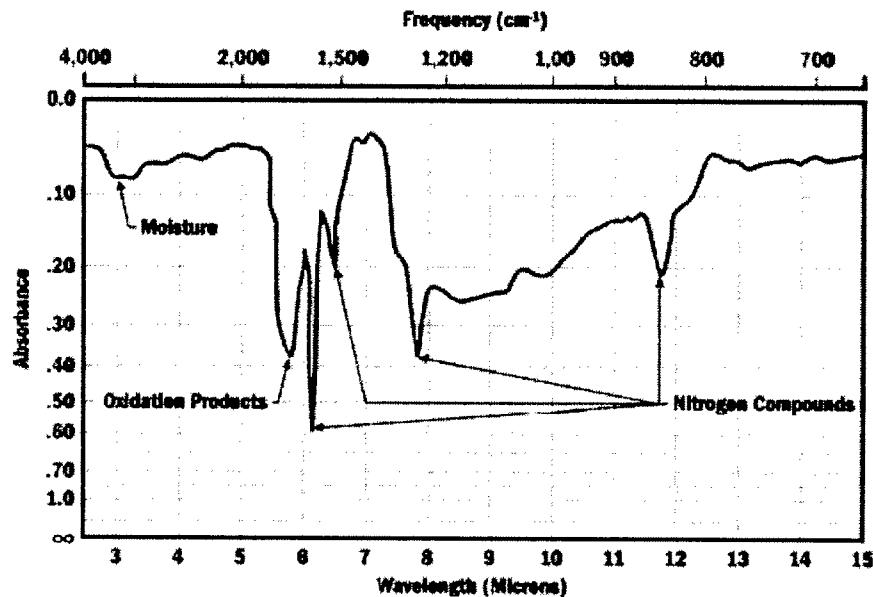


Figure 3. Infrared Analysis Can Immediately Determine Nitration and Oxidation Levels.